CLAIMS

1. A process for olefin polymerization, comprising the acts of:

contacting in a reaction mixture under slurry polymerization conditions reactants comprising at least one olefin monomer with a heterogeneous catalyst system comprising one or more catalytic metal compounds;

making a polyolefin; and

monitoring the process by using Raman spectrometry equipment to provide an output signal representative of at least one of the reactants and the polyolefin.

2. The olefin polymerization process of claim 1, wherein the output signal is representative of a concentration of at least one of the reactants and the polyolefin.

3. The olefin polymerization process of claim 1, comprising the act of adjusting the olefin polymerization process in response to the output signal provided by the Raman spectrometry equipment.

4. The olefin polymerization process of claim 1, wherein the olefin polymerization process is adjusted by adjusting the concentration within the reaction mixture of at least one chemical component within the reaction mixture.

5. The olefin polymerization process of claim 3, wherein the olefin polymerization process is adjusted by adjusting one or more polymerization conditions, wherein the polymerization conditions comprise at least one of polymerization temperature, polymerization pressure, withdrawal of the reaction mixture from the reactor, and circulation rate of the reaction mixture within the reactor.

6. The olefin polymerization process of claim 1, wherein the Raman spectrometry equipment is operatively connected to a Raman fiber optic probe that is in contact with at least one of the reaction mixture and the polyolefin.

7. The olefin polymerization process of claim 6, wherein the Raman fiber optic probe comprises fused silica fiber optic cables within a protective metal sheath.

8. The polymerization process of claim 1 wherein the Raman spectrometry equipment comprises low resolution Raman equipment.

9. The polymerization process of claim 8 wherein the Raman low resolution spectrometry equipment has a resolution in the range of from about 15 wavenumbers to about 30 wavenumbers.

10. The method of claim 1, wherein the at least one olefin monomer comprises ethylene.

11. The method of claim 10, wherein the reaction mixture comprises at least one of a comonomer, hydrogen, and a co-catalyst.

12. The method of claim 11, wherein a comonomer is contacted with the ethylene, and the comonomer comprises at least one of 1-butene, 1-pentene, 4-methyl-1-pentene, and 1-hexene.

13. The polymerization process of claim 1, wherein the reaction mixture is within a loop polymerization reactor.

14. The polymerization process of claim 13, wherein the act of monitoring by comprises the act of analyzing effluent from the loop polymerization reactor.

15. The polymerization process of claim 1, wherein the olefin polymerization process is performed in two or more reactors connected in series, wherein effluent from an upstream reactor is provided as input to a downstream reactor, wherein the monitoring step comprises the act of determining a concentration of the monomer in the effluent by Raman spectrometry equipment, and the adjusting act of comprises the act of providing an amount of at least one of monomer and comonomer in addition to the effluent to the downstream reactor.

16. A method for monitoring and controlling an olefin polymerization reaction comprising the acts of:

contacting components of a reaction mixture in a polymerization reactor under polymerization conditions, the components comprising a monomer, a diluent, and a catalyst system;

using Raman spectrometry equipment to obtain a Raman spectrum;

obtaining a concentration of at least one of the components based upon the Raman spectrum; and

adjusting at least one polymerization condition in response to the concentration of the at least one of the components.

17. The method of claim 16, comprising the acts of:

obtaining a Raman spectrum of the reaction mixture; and

determining the concentration of at least one of the components through the use of a calibration model.

18. The method of claim 17, comprising the act of developing the calibration model using partial least squares analysis.

19. The method of claim 18, wherein the Raman spectrometry equipment is low resolution Raman spectrometry equipment.

20. The method of claim 19, wherein the low resolution Raman spectrometry equipment has a resolution of about 15 wavenumbers to about 30 wavenumbers.

21. The method of claim 17, comprising the act of developing the calibration model for the Raman spectrometry equipment to be used in the olefin polymerization reaction by calibrating in a process for converting ethylene to 1-hexene.

22. A method of monitoring and controlling a polyolefin production process, comprising the acts of:

exposing an in-situ polymerization mixture to radiation emission from a spectroscopic probe;

acquiring a spectroscopic signal from the in-situ mixture in substantially real-time in response to the radiation emission via the spectroscopic probe; and

analyzing the spectroscopic signal to determine at least one property of interest of the in-situ mixture, wherein the in-situ mixture comprises at least one of a polyolefin, an olefin monomer, a comonomer, a diluent, a catalyst, a co-catalyst, and hydrogen.

23. The method as recited in claim 22, wherein the spectroscopic probe comprises a Raman probe.

24 The method as recited in claim 22, wherein the in-situ mixture comprises at least one of a mixture in a reactor, a mixture fed to the reactor, a mixture exiting the reactor, and a mixture exiting a flash vessel.

25. The method as recited in claim 24, wherein the reactor comprises at least one of a loop slurry reactor and a gas phase reactor.

26. The method as recited in claim 25, wherein the mixture exiting the flash vessel comprises at least one of a flash gas exiting in the flash vessel overhead and a substantially polyolefin stream exiting in the flash vessel bottom discharge.

27. The method as recited in claim 22, wherein the property of interest comprises a concentration in the in-situ mixture of at least one of a monomer, a comonomer, a diluent, and hydrogen.

28. The method as recited in claim 22, comprising at least one of the acts of:

adjusting at least one addition rate of a feed stream to a polymerization reactor in response to the property of interest;

adjusting a concentration of at least one component in a feed stream to a polymerization reactor in response to the property of interest; and

adjusting a concentration of at least one component in a polymerization reactor in response to the property of interest.

29. A method of monitoring and controlling a polyolefin production process, comprising the acts of:

exposing a polyolefin polymerization mixture to a radiation emission from the Raman spectroscopic probe;

acquiring a Raman spectroscopic signal from the mixture in response to the radiation emission via the Raman spectroscopic probe; and

analyzing the spectroscopic signal to determine at least one property of interest of the mixture, wherein the mixture comprises at least one of a polyolefin, an olefin monomer, a comonomer, a diluent, a catalyst, a co-catalyst, and hydrogen.

30. The method as recited in claim 29, wherein the Raman spectroscopic signal is acquired in substantially real-time, and the mixture comprises an in-situ mixture in at least one of a polymerization reactor feed stream, a polymerization reactor, a polymerization reactor discharge, a polymerization flash separator, and a polymerization flash separator discharge.

31. The method as recited in claim 29, wherein the property of interest comprises a concentration of at least one of a solid polyolefin, an olefin monomer, a comonomer, a diluent, and hydrogen.

32. The method as recited in claim 29, wherein the mixture comprises ethylene and hexene, and wherein low-resolution Raman is used to determine the concentration of hexene in the mixture.

33. The method as recited in claim 29, wherein the mixture is an off-line sample collected from at least one of a polymerization reactor feed stream, a polymerization reactor, a polymerization reactor discharge, a polymerization flash separator, and a polymerization flash separator discharge.

34. The method of claim 29, comprising the act of adjusting the amount of at least one of a reactor feed component and a reactor component, in response to the property of interest, wherein the reactor feed component and reactor component comprise at least one of a catalyst, a co-catalyst, a monomer, a comonomer, a diluent, and hydrogen.

35. A polyolefin production process, comprising:

means for polymerizing an olefin to a polyolefin;

means for exposing an in-situ polymerization mixture to radiation emission from a Raman spectroscopic probe;

means for acquiring a Raman spectroscopic signal from the in-situ mixture in substantially real-time in response to the radiation emission via the Raman spectroscopic probe; and

means for analyzing the Raman spectroscopic signal to determine at least one property of interest of the in-situ mixture, wherein the in-situ mixture comprises at least one of a polyolefin, an olefin monomer, a comonomer, a diluent, a catalyst, a co-catalyst, and hydrogen.